United States Patent Office

3,376,171

Patented Apr. 2, 1968

3,376,171

COPPER ALLOY

Anthonius Catharina Wilhelmus Verdonk, Eindhoven, and Pieter Johannes Bernard Kradolfer, Zeist, Netherlands, assignors to N.V. Cirex, Almelo, Netherlands

No Drawing. Continuation of application Ser. No. 359,542, Apr. 3, 1964. This application Nov. 1, 1966, Ser. No. 591,341

Claims priority, application Netherlands, Apr. 11, 1963, 291,498

3 Claims. (Cl. 148—3)

ABSTRACT OF THE DISCLOSURE

A method of manufacturing a fine-grained copper alloy in which an alloy of copper containing beryllium and between 1.25 and 2% by weight of cobalt are cast by heating the alloy to a temperature between 1100° and 1200° C.

This application is a continuation of application Ser. No. 359,542, filed Apr. 3, 1964, now abandoned.

This invention relates to copper alloys containing beryllium and cobalt as alloy elements which determine substantially the possibility of precipitation hardening of the alloy.

The alloys of this kind usually contain between 1.9 and 2.1% by weight of beryllium and about 0.35% by weight of cobalt. In practice, such alloys, after having been rolled, are usually annealed at about 800° C. for 2 to 3 hours in order completely to dissolve the beryllium. After quenching in water an alloy results which is soft and excellently workable. The alloy may be hardened by subsequent heating for some time at a temperature between 250° C. and 300° C. During the heating process beryllium is precipitated, resulting in a considerable increase in the hardness and tensile strength of the alloy. Further increase in hardness may be obtained if the alloy is cold deformed between quenching and tempering (age hardening).

If the alloy is cast in molds in order directly to obtain therefrom an object in its definite shape it is not possible to give the object that hardness and tensile strength which are obtainable in objects which have been intermediately wrought, cold rolled or drawn.

On the one hand, this is in certain cases attributed to imperfections in the structure which may occur to a certain extent in cast material. On the other hand, a coarse precipitation of α-crystals occurs during coagulation. Even with a very long period of annealing at about 800° C., followed by quenching and tempering, it is still not possible to obtain that hardness and tensile strength which are possible with the fine-granular or intermediately rolled material.

It is an object of the invention to provide an alloy which may be cast and wherein the objects cast therefrom may be given such a hardness and tensile strength by solution annealing, quenching and tempering as may be obtained in the rolled alloys usually employed only by using a considerable cold deformation between quenching and tempering.

It has been found that this result may be achieved by considerably increasing the percentage of cobalt and choosing it between 1 and 2% by weight with a beryllium

content of about 1.9 to 2.1% by weight, the remainder being copper.

The alloy found is thus characterized in that it contains between 1.9 and 2.1% by weight of beryllium, between 1 and 2% by weight of cobalt, the remainder being copper.

The alloy may be obtained by putting together between 1.9 and 2.1% by weight of beryllium, between 1 and 2% by weight of cobalt and between 95.9 and 97.1% by weight of copper, following by melting together by methods usually employed in the manufacture of copper beryllium alloys.

A suitable manufacturing method consists in melting together, for example, 52% by weight of a copper alloy containing 4% by weight of beryllium, 1.25% by weight of cobalt and 46.75% by weight of copper in a ceramic crucible under nitrogen.

Alloys according to the invention are found to distinguish from the conventional alloys in the size of the grains formed during solidifying after the casting process. Alloys according to the invention permit obtaining castings having a very fine-grain structure wherein the lower limit is found to lie at about 1.0% by weight of Co. Upon casting an alloy of the composition 2% by weight of Be, 1.0% by weight of Co, and the remainder copper, the following was found:

If the casting temperature was between 1100° C. and 1130° C. and casting took place in molds such as obtained in the lost-wax method (investment casting) at a temperature of 200° C. then parts of small sections (diameter 10 mm.) showed in fine-grained structure and parts of large sections (diameter 28 mm.) showed a coarser-grained structure. An alloy containing the same amount of beryllium and 1.25% by weight of cobalt showed under these condtions a fine-grained structure in any section. However, if the rate of cooling was higher such as, for example, in shell molds (shell casting) the structure was fine-granular in any section also in the alloy containing 1.0% by weight of cobalt. It has been found that the structure again becomes a little coarse-grained with an increasing percentage of cobalt. Above about 2.0% by weight the structures are found to be again as coarse-grained as below 1.0% by weight under conditions otherwise unvaried. Alloys that produce a fine-grained structure independent of the rate of cooling are obtained with 1.9–2.0% by weight of Be, 1.25–2% by weight of Co, balance copper.

However, the fine-granular structure obtained upon casting the alloys according to the invention, which have a Co-content between 1% and 2%, has formed to be the very condition for maximum hardening after a treatment known as precipitation hardening and consisting in solution annealing, quenching and then tempering (age hardening).

It has also been found that the casting temperatures may be chosen between 1100° C. and 1200° C., but preferably near 1100° C. Coarse-grained structures occur at casting temperatures above 1200° C. for any percentage of cobalt.

The castings may be solution-annealed in the normal way at a temperature between 780° C. and 800° C. for, for example, 1 hour, or as much longer as is considered necessary for the structure. After quenching to room temperature, for example in water, the castings are hardened by heating to a temperature between 290° C. and 370° C. Maximum hardness during tempering is usually obtained by heating at a temperature between 345° C. and 355° C. for 4 to 6 hours. For the rolled alloys usually employed, this period is about 4 hours and the temperature about 310° C.

Alloys of great hardness and tensile strength which are economically interesting are obtained with 1.9 to 2.0% by weight of Be, 1.25 to 1.35% by weight of Co, the rest copper.

Several data in relation to such an alloy are collected in the table below. For comparison several data of a rolled and cold-deformed alloy and of cast alloys of the usual composition are included.

No.	Copper alloy containing in percent by weight		Treatment	Hardness VPN/10, kg./sq. mm.	Tensile strength, kg./sq. mm.	Maximum ductility in percent
	Be	Co				
1	2.1	0.3	Rolled, solution annealed at 800° C., quenched and 40% cold deformed and then precipitation hardening for maximum strength.	390–420	135	1
2	2.1	0.3	Cast, solution annealed at 800° C., quenched and precipitation hardening for maximum strength.	350	80	2
3	2.0	1.25	Cast, solution annealed at 800° C. for 1 hour, quenched and heated at 350° C. for 4.5 hours.	410	135	1.5

From the above table it appears that the properties of the alloy according to the invention are fully comparable with those of the rolled and cold-deformed alloy of the usual composition.

For example, pick-locks were manufactured from the alloy (2% of Be, 1.25% of Co, rest copper) by precision casting. The pick-locks were equivalent to wrought-steel spanners with equal thickness and strength (Rockwell-Vickers and Brinell hardness and maximum bending moment without permanent deformation).

Alloys in accordance with the invention may be used inter alia for the manufacture of machine parts requiring, in addition to a high tensile strength, satisfactory thermal and electrical conductivity and for the manufacture of sparkless tools by casting. When using such alloys, it is possible to obtain a considerable saving in the manufacturing cost of such products. The alloy is thus especially suitable for so-called precision casting.

Copper alloys, which contain, in addition to beryllium, between 1 and 2% by weight of cobalt are known. However, such known cast alloys contain an amount of beryllium which is considerably less, usually less than 1% by weight. The maximum strength obtainable with such alloys is smaller than that obtained with alloys in accordance with the invention.

Alloys according to the invention may also contain small amounts of silicon, magnesium, aluminium, iron and other metals as impurities. Amounts up to 0.5% by weight of iron, vanadium, and titanium or other impurities do not usually interfere with the good properties of alloys in accordance with the invention.

What is claimed is:

1. In the method of manufacturing a fine-grain alloy, consisting of between 1.9 and 2.1% by weight of beryllium, between 1.25 and 2% by weight of cobalt and the balance copper, the step of casting said alloy at a temperature between 1100° C. and 1200° C.

2. A method as claimed in claim **1** in which the alloy, after casting, is solution annealed at a temperature between 780° C. and 800° C. for at least one hour, and quenched in water.

3. A method as claimed in claim **1** in which the alloy has great hardness and tensile strength and consists of between 1.9 and 2.0% by weight of beryllium, between 1.25 and 1.35% by weight of cobalt and the remainder copper.

References Cited

UNITED STATES PATENTS

2,088,219	7/1937	Silliman	148—160
2,166,794	7/1939	Brophy	75—153 X
2,172,639	9/1939	Hessenbruch	75—153
2,192,495	3/1940	Hessenbruch	75—153 X

OTHER REFERENCES

Donachie: "The Role of Beryllium Copper As An Engineering Material," 6 pages.

"Berylco 20CR, Alloy Digest," Cu18, July 1954, Engineering Alloy Digest Inc., N. J.

"Berylco 10CR, Alloy Digest," Cu59, February 1958, Engineering Alloy Digest Inc., N.J.

CHARLES N. LOVELL, *Primary Examiner.*